VOL. 7 MARCH 1964 No. 2

metric measures

JOURNAL OF WEIGHTS AND MEASURES

40 NAYE PAISE

THE PUBLICATIONS DIVISION

ABBREVIATION FOR METRIC UNITS

(1) DECIMAL MULTIPLES AND SUB-MULTIPLES

Prefix		Value in Terms of Unit	Abbreviation
Kilo	..	1,000	k
centi	..	$0\cdot01(10^{-2})$	c
milli	..	$0\cdot001(10^{-3})$	m
micro	..	$0\cdot000\,001(10^{-6})$	u

(2) WEIGHTS

Denomination		Value	Abbreviation
tonne	..	1,000 kg	t
quintal	..	100 kg	q
kilogram	..	1 kg	kg
gram	..	1 g	g
milligram	..	1 mg	mg
carat	..	200 mg	c
(3) CAPACITY			
kilolitre	..	1 000 1	kl
litre	..	1 1	l
millilitre	..	1 ml	ml
(4) VOLUME			
cubic metre	..	m^3	m^3 or cu m*
cubic centimetre	..	cm^3	cm^3 or cu cm*
cubic millimetre	..	mm^3	mm^3 or cu mm*
(5) LENGTH			
kilometre	..	1 000 m	km
metre	..	1 m	m
centimetre	..	1 cm	cm
millimetre	..	1 mm	mm
micron	..	1/1 000 mm or 10^{-3}mm	um
(6) AREA			
square kilometre		1 000 000 m^2	km^2 or sq km*
square metre	..	1 m2	m^2 or sq m*
square centimetre		1 cm^2	cm^2 or sq cm*
square millimetre		1 mm^2	mm^2 or sq mm*
(7) LAND MEASURE			
are	..	100 m^2	a
hectare	..	100 a	ha
centiare	..	m^2	ca

*Both these abbreviations are current, but the first set should preferably be used. The former abbreviation is used more commonly internationally than the latter.

Rules for Abbreviations :

(1) Do not make any change, such as addition of 's' to indicate plurality *e.g.,* write 1 kg, 10 kg, 20 g, 5 g, 10 t, 20 ml, 27l, 165 km, 2 mm, 100 cm^3, 66 km^2.

(2) Do not capitalize the abbreviations. For example, do not write 1 Kg, 2 Kg, 20 MM, 50 MM; the right way is to write 1 kg, 2 kg, 20 mm, 50 mm, etc.

(3) Do not use any other abbreviations except those given above.

EDITORIAL BOARD

S. L. KUMAR, Former Principal, Patiala Engineering College, Patiala.

U. S. MOHAN RAO, Director, Publications Division, Ministry of Information and Broadcasting, New Delhi.

A. NAGARAJA RAO, Chairman, Heavy Engineering Corporation, Ranchi.

P. N. NAYER, Director, Weights & Measures, Ministry of International Trade, New Delhi.

PITAMBER PANT, Private Secretary to Chairman, Planning Commission, New Delhi.

H. L. ROY, Chairman, Indian Decimal Society, Calcutta.

B. N. SASTRI, Former Chief Editor, Council of Scientific and Industrial Research, New Delhi.

K. V. VENKATACHALAM, Joint Secretary, Ministry of Industry, New Delhi.

LAL, C. VERMAN, Director, Indian Standards Institution, New Delhi.

V. B. MAINKAR, Deputy Director, Weights & Measures.

—*EDITOR*

metric measures

JOURNAL OF WEIGHTS AND MEASURES

MINISTRY OF INTERNATIONAL TRADE

Vol. 7 MARCH 1964 (PHALGUNA 1885) No. 2

CONTENTS

Development of Length and Area Measures in South India—Part 2 .. 3
L. Raju & V. B. Mainkar

Working Standard Balances : Part 4—Knife-edges 13
B. R. Dhurandhar

Ten Years of Weights & Measures Division in NPL 16

Change-over in Industries 20

A Move to Metric Has Wide Support 23

Simple Area & Volume Conversions 26
M. L. Kalsi

News & Views 28

Book Review 30

Cover design by R. Sarangan

Annual Subscription Rs. 2·00 **Single Copy 40 nP.**

metric measures

METRIC MEASURES is published every two months.

METRIC MEASURES provides information to the general public on the administrative, commercial, educational, industrial, historical and other aspects of weights and measures, with particular reference to the introduction of the metric system in India.

Contributions for publication should be sent to the Editor, METRIC MEASURES, Directorate of Weights & Measures, Ministry of International Trade, Udyog Bhavan, New Delhi.

Enquiries regarding subscriptions and supply of copies should be addressed to the Business Manager, Publications Division, Ministry of Information and Broadcasting, Old Secretariat, Delhi-6.

Articles published in the Journal may be reproduced. Credit line should read : METRIC MEASURES.

The opinions expressed by authors are not necessarily those of the Government.

Development of Length and Area Measures in South India-Part 2

L. RAJU & V. B. MAINKAR
Ministry of International Trade,
New Delhi

IN Part 1, it was pointed out that length and area measures were intimately linked with each other. Measurement of areas of land for revenue purposes is an important function for the Government and the British were keen to adapt many of the then existing length measures in terms of their own units of length like the inch, foot or the yard.

There were, however, indigenous length units in use before the British came. Many of these could still be noticed in trade till recently. Some of them were also used in ancient times for measuring land areas. To estimate the length of these units it was necessary to trace the history of some of the important length units from the earliest times. It was noticed that although the Indus Valley civilization had perhaps a well-developed system of length and area units, we do not have enough knowledge of them at present. The Vedic times also had a system of length and area measures, but a systematic effort to establish their relations was not made until Kautilya enumerated them in his *Arthashastra*. In view of the fundamental *character of the data presented in the Arthashastra*, the various units recorded therein were analysed and their values derived in terms of metric units.

Post-Arthashastra Changes

In the wake of Kautilya's times, numerous changes seem to have taken place in the domain of length and area measures. It is not possible to trace why such changes occurred. Perhaps a need to alter the old units to suit the convenience of the trade or calculations may have been keenly felt. Anyhow, the result was that a strange mixture of tradition and arithmetical novelty came into use, the interpretation of which led to many surprising deductions which have been the root cause of the bewildering variety of length and area measures in later years.

If the examination of the new trends which emerged after Kautilya is to be fruitful we should first assess the practical considerations which could have necessitated a change. The one reason that immediately strikes one is that the principal hasta measures of *Arthashastra* viz. ½ of kisku of 42 angula, 24 and 28 angula, could not all be divided by any single number. Of these three numbers 24 had the best divisibility; it could be divided by 2, 3, 4, 6, 8 and 12. Neither 21 nor 28 had this advantage as they were divisible by 3 and 7 in the case of 21 angula and 2, 4, 7 and 14 for the 28 angula. For trading as also for other purposes it would have been

convenient to divide the commercial hasta into 24 parts instead of 28 parts as was the custom. This division into 24 parts could be achieved in two ways :

(1) Keep the length of the measure (50 cm) unchanged but divide it into 24 parts, thus increasing the angula,

or

(2) Keep the angula unchanged, and reduce the length to 24 angula (i.e. 42·86 cm), thus shortening proportionately all the other length measures.

It is obvious from later traditions, that the former course was adopted, perhaps because it meant that a complete change of the numerous length measures dependent on the commercial hasta would not be involved. This, however, involved an increase in the dimension of the angula and yava in the proportion of 28/24 or 7/6.

An almost exact parallel to this change occurred in the immediate past in India when decimal coinage was adopted. There was considerable discussion whether the old pice should be the principal unit and the rupee increased or the rupee should remain constant and be subdivided into 100 units. The latter course was preferred as it caused the least disturbance in the monetary system.

The alteration of the subdivision of the commercial hasta of 50 cm also involved an alteration of the two other hasta units (viz. the *Arthashastra* hasta of 24 angula and ½ kishku of 21 angula) which were also used for certain purposes. It is possible that people were not willing to discard these measures as superfluous. They had, therefore, to be accommodated in the new scheme of measures. Here again there were two possibilities:

(1) Reduce the 28 angula length to 24 parts, and reduce the content of the remaining two hasta proportionately. In this case the enlarged angula (in proportion of 28/24 or 7/6) remains constant for the three hasta, but the angula content varies.

(2) Divide all the three hasta units into 24 parts but define the angula in such a manner that the dimensions of the hasta remain unaffected. The best method would be to define the angula as 6, 7 and 8 yava of enlarged dimensions (7/6).

From later literature it would appear that both these systems were adopted, depending perhaps on the preference of the people of a region. With the passage of time, however, the second system appears to have slowly become more popular. We may analyse the salient points of the two trends in greater detail to get an idea of how the systems worked.

Proportionate Changes in Hasta

We may first consider the case where the *Arthashastra* hasta of 28 angula was reduced to 24 parts and others were reduced proportionately. This method gives the values recorded in Table 1.

TABLE 1—PROPORTIONATE CHANGES IN HASTA

Sl. No.	Arthashastra Hasta Angula (cm)	New Hasta New Angula (cm)	Change in Angula	
			Arthashastra	New
(1)	28(50)	24(50)	1·786 cm	2·08 cm
(2)	24(42·86)	21(43·75)	1·786 cm	2·08 cm
(3)	21(37·50)	18(37·50)	1·786 cm	2·08 cm

In Table 1 only the hasta units are examined. Other units dependent on them like danda or yojana, would not change in length unless their definitions were altered. Some important points should, however, be noted from Table 1.

The angula, which was apparently related with the dimension of the middle finger in

Kautilya's days, does not retain that relationship now. Its value increases from 1·786 cm to 2·08 cm. The yava unit also increases in length proportionately. The dimensions of the units related to the limbs of man, such as palm, vitasti etc. also lose their meanings as a result of this change. It must be stressed that much of the confusion in later literature arises from the fact that the names of units and the multiples and submultiples remained unaltered. Fantastic theories were evolved to correlate these new measures with the limbs of man.

Secondly, if the 28 angula hasta is reduced to 24 parts, the 24 angula would automatically be reduced to $\frac{24 \times 24}{28} = 20 \cdot 57$ angula. So the aratni, i.e. 24 angula hasta of *Arthashastra*, was reduced to an awkward number of angula i.e. 20·57. It was, therefore, rounded to 21. We cannot be sure whether the original length of 42·86 cm was retained or the new length of 43·75 cm was adopted. We may, for our purposes, assume that both values are correct.

We may illustrate these two points. The *BrahmandaPurana*[17] (1.7.95—101; 4.2.13—26) gives the following relationships.

8 yava	= 1 angula	
10 angula	= 1 vitasti	
21 angula	= 1 ratni	=(43·75 cm or 42·86cm)
24 angula	= 1 hasta	=(50 cm)
42 angula or 2 ratni	= 1 kishku	=(87·50 or 85·72 cm)
4 hasta	=1 dhanu or danda	=(2m)
2 dhanu	=1 nali	=(4m)
2 000 dhanu	=gavyuti	=(4 km)
8 000 dhanu	=yojana	=(16 km)

In the *Brahmanda Purana* the ratni or aratni is taken as 21 angula, whereas it ought to be 24 angula according to *Arthashastra*. The hasta is 24 angula and is distinguished from the ratni. It is obviously equal to the *Arthashastra* hasta of 28 angula. Note that names like vitasti and angula occur but have enhanced lengths in view of the aratni of 21 angula. The vitasti which is normally half of ratni of 24 angula now has 10 angula, and the ratni 21. It is also noteworthy that the kishku is equal to 42 new angula. This kishku was in use in India for a long time, but there was always a controversy whether it should be taken as 41, 41·5 or 42 angula. It should now be obvious why this controversy arose. We shall refer to it again later when we examine Akbar's length measures.

Proportionate Changes in Angula

Let us now examine the second method. Here both the angula and yava are affected in a manner different from the first method we examined. In this case, each hasta is divided into 24 angula but the angula contains 8, 7 or 6 yava. The yava is also larger than the *Arthashastra* yava. So both the angula as well as the yava acquire different magnitudes, the hasta being uniformly divided into 24 parts or angula. This interesting relation is shown in Table 2.

TABLE 2—PROPORTIONATE CHANGE IN ANGULA

Sl. No.	Arthashastra Hasta			New Hasta		
	Angula	Yava	cm	Angula (cm)	Yava	cm
(1)	28	28 × 8 =224	50	24 (2·08)	24 × 8 =192	50
(2)	24	24 × 8 =192	42·86	24 (1·82)	24 × 7 =168	43·75
(3)	21	21 × 8 =168	27·50	24 (1·59)	24 × 6 =144	37·50

An examination of Table 2 yields many interesting results. The new angula has values of 2·08, 1·82 and 1·59 cm respectively. The yava also increases in the proportion of 7/6. Thus 192×7/6=224 yava, 168×7/6 =196 yava and 144×7/6=168 yava. It will be noticed that here also the aratni (Sl. No. 2) gives rise to the same irregularity as noticed earlier; it is larger than the *Arthashastra* aratni by about 1/2 angula. Then again the yava and the angula have totally different dimensions from those used in *Arthashastra*.

The difference in the dimensions of the yava and angula as between the *Arthashastra* and the two later traditions indicated above should be carefully observed. It should again be stressed that any attempt to relate these later units with the actual lengths of yava, angula, palm, vitasti or hasta are bound to give erroneous results. The *average* lengths of these natural units could be utilized for explaining only the *Arthashastra* and earlier units.

The different hasta based on 6, 7 and 8 yava may be illustrated by examples drawn from mathematical and similar other sources.

In the *Ganita Tilaka*[18] by Sripati (1040 AD) the following table occurs for *Kshetra-Vyavahara* i.e. measurement of area etc.

6 yava (without tasu)	= 1 angula
24 angula	= 1 hasta, hastika, pani (37·5 cm)
4 pani	= 1 danda or dandaka (1·5 m)
20 dandaka	= 1 rajju (30 m)
2 rajju (samasri)	= 1 nivartana $(30\times 2)^2$= (3600 m^2)
2 000 danda	= 1 krosa (3 km)
4 krosa	= 1 yojana (12 km)

Here the angula of 6 yava is used for all length and area measurements. It is assumed that this angula gives the hasta of 37·5 cm.

Another interesting table occurs in *Lalitavistar*[19] written perhaps around 2nd century AD. In this table the progression is by seven from the smallest unit up to yava. We may take it that this progression is only notional. From the yava onwards the table is as follows:

7 yava	= 1 anguliparvan
12 anguliparvan	= 1 vitasti (21·88 cm)
2 vitasti	= 1 hasta (assumed to be 43·75 cm)
4 hasta	= 1 dhanusya (1·75 m)
1,000 dhanusya	= 1 krosa (1·75 km)
4 krosa	= 1 yojana (7 km)

The above two tables show that the 6 and 7 yava angula have been used as basic units, without in any way differentiating between the two different vitasti or hasta or danda or even yojana. Each of them acquires a different value.

In his *Ganita-Sara-Sangraha*[20] Mahavira (877 AD), a Jain mathematician, records the following table, given here from yava onwards.

8 barley measures	= 1 angula or vyavaharangula
6 angula	= 1 foot measure (measured across) (12·5 cm)
2 feet	= 1 vitasti (25 cm)
2 vitasti	= 1 hasta (assumed to be 50 cm)
4 hasta	= 1 danda (2 m)
2 000 danda	= 1 krosa (4 km)
4 krosa	= 1 yojana (16 km)

The common tradition of length and area measures in later times was laid down by Bhaskaracharya (1180 AD) in his *Lilavati*[21]. His tables were taken as authoritative and the units recorded by him were used in many parts of the country. We have already established that the hasta of Bhaskaracharya should be taken as 50 cm[1]. The table with metric equivalents is given below:

8 yava	= 1 angula (2·08 cm)
24 angula	= 1 hasta (50 cm)
4 hasta	= 1 danda (2 m)
2 000 danda	= 1 krosa (4 km)
4 krosa	= 1 yojana (16 km)

10 hasta	=	1 vamsa (5m)
20 × 20 vamsa	=	1 nivartana (1 hectare i. e. a square of 200 hasta a side)

This table is interesting. The nivartana of Bhaskaracharya works out to be 1 hectare. The *Arthashastra* gave us a nivartana of 10581 m^2.

We have now examined a few examples of the second type of change i.e. angula being 6, 7 or 8 yava. An example of how other attempts to devise sets of tables could have added to the confusion would be of interest.

The *Sukraniti*[22] (1.196-210) gives an interesting table for linear and area measures. Two angula are defined, one of 5 barleys which is equal to the breadth of the middle finger and the second of 8 barleys which is equal to the length of the middle portion of the middle finger. These two are taken as the fundamental units for deriving the length and area units. The 8 yava measures are called Prajapatya and 5 yava Manu. His table works out as follows:

Unit	Prajapatya	Manu
Angula	8 yava	5 yava
Kara	24 angula (68·58 cm)	24 angula (42·86 cm)
Danda	4 kara (2·743 m)	5 kara (2·143 m)
Krosa	5 000 kara (3·429 km)	4 000 kara (1·7144 km)
Nivartana	25 × 25 danda (68·58 × 68·58 m) = 4703·2 m^2	25 × 25 danda (53·575 × 53·575) = 2870·8 m^2

The values for the various units are derived by taking the 5 barley angula as equivalent to the *Arthashastra* angula, as they both represent the breadth of the middle finger. This is a rare instance of a 5 yava angula. It should be noted that the Prajapatya angula or kara cannot be related with these limbs of man. These are treated by *Sukraniti* merely as a convenient method of progression of the units.

Barnett[23] quotes the following table from a Jain *Ganita* as quoted by Peterson, in the *Third Report on the Search for MSS*, p. 7 :

4 tila (sesame seeds)	=	1 yava (corn)
4 yava	=	1 angula (finger)
4 angula	=	1 mushti (fist)
4 mushti	=	1 hasta or kara (cubit)
4 hasta	=	1 danda etc.

It is obvious that the above table is somewhat fanciful. Whether it had a real practical base or not is disputable.

Mahavira, Bhaskaracharya and many others use the 8 yava angula, the various units retaining the same old names. The 8 yava angula was apparently the most commonly used in trade. The units based on 7 and 6 yava angula also had their uses for certain purposes.

A confirmation of the traditions examined above occurs unexpectedly in a much later source, the *Ain-i-Akbari*[24] written in the 16th century A.D. A brief analysis of Akbar's measures may not, therefore, be out of place here.

Akbar's Contribution

The *Ain-i-Akbari* in *A*in 8 states :

Throughout Hindustan there were three such(length) measures current viz. long, middling and short. Each was divided into 24 equal parts and each part called tassuj. A tassuj of the first kind was equal to 8 ordinary barley-corns, placed together breadthwise and the other two respectively to 7 and 6 barley corns.

The use pattern of the measures is recorded as follows :

Long Measure

(8 yava = angula = tassuj)

Measurement of cultivated lands, roads, distances, forts, reservoirs and mud walls.

Middling Measure

(7 yava = angula = tassuj)

Measuring buildings of stone and wood, bamboo built houses, places of worship, wells and gardens.

Short Measure

(6 yava = angula = tassuj)

Measuring cloth, arms, beds, seats of states, sedan chairs, palanquins, chairs, carts and the like.

The *Ain-i-Akbari* then records the various gaz measures used in India and elsewhere and finally informs us :

His majesty in his wisdom, seeing that the variety of measures was a source of inconvenience, abolished them all and brought the medium gaz of 41 digits in general use. He named it Ilahi gaz and it is employed by the public for all purposes.

What is the length of this Ilahi gaz? The answer to this question would establish whether it was based on Indian or foreign traditions. Many attempts have been made to determine the length of the Ilahi gaz. Duncan[25], after prolonged enquiry, estimated it at 33·6 in (85·34 cm), while others have valued it from 33 to 34·25 inches, a mean of these is 33·75 inches (85·73 cm). Jervis thinks it was exactly 33·5 inches (85·09 cm). In 'settling' the N.W. Provinces, a gaz of 33·5 inches (85·09 cm) was used. The Ilahi gaz has also been estimated at 30·75 inches (78·11 cm) by Moreland[26], and at 32 inches (81·28 cm) by Cracroft[27]. The most favoured length is, however, about 33·5 to 33·6 inches (85·09 to 85·34 cm).

The analysis we have made so far shows that the Ilahi gaz could have been derived from the kisku of 42 angula mentioned in the post-*Arthashastra* literature. But we must examine this kisku in relation to the *Arthashastra* units to understand its significance. The post-*Arthashastra* kisku of 42 angula is perhaps derived from twice the *Arthashastra* aratni of 24 angula i.e. kisku must be 48 angula. When the hasta was revised later on from 28 angula to 24 angula (50 cm), the 48 angula unit became $\frac{48\times 24}{28} = 41\text{-}1/7$ angula. The 1/7 angula may be neglected. Then at the rate of 24 angula = 50 cm, 41 angula would be 85·417 cm (33·63 in.). The length of the Ilahi gaz, if calculated as above on the basis of the *Arthashastra* tradition, works out to about 85·42 cm. This is in excellent agreement with the value generally accepted. If we do not neglect the 1/7 angula, the Ilahi gaz becomes 85·71 cm.

The bigha of Akbar was 60×60 Ilahi gaz. It works out to 2626·583 m² (3142 sq. yd). It is not surprising that the Akbari bigha is almost equal to the smaller nivartana of *Arthashastra* (2645·3 m²) as it is derived on the same principles. It would have been exactly the same had we not neglected the 1/7 angula in defining the Ilahi gaz. The basic calculation in both is the same.

There is another significant statement in Ain 8 that an 'Akbar Shahi gaz of 46 fingers was used as a cloth measure'. What is this 46 finger gaz? It can be explained as the converted *Arthashastra* hasta of 54 angula. $\left(\frac{24\times 54}{28} = 46\text{-}2/7 \text{ angula.}\right)$ It would work out to 95·83 cm, if we neglect the 2/7 angula and take the 24 angula as equal to 50 cm and to 96·43 cm, if we do not neglect 2/7 angula.

We thus obtain confirmation of the continuance of *Arthashastra* traditions under other names and garbs continuously through centuries.

Larger Measures

So far we have discussed mainly the units of hasta or double hasta and some of the area measures. Larger length units are danda or dhanusha, (4 hasta), the krosa, also called gavyuti, goruta etc. (1 000 or 2 000 danda) and the yojana, usually equated with 4 krosa. It should now be obvious that depending upon the length of the hasta used for measurement, the yojana or krosa would have differing values.

The larger length measures we have examined are recorded in Table 3.

TABLE 3—DIMENSIONS OF LARGER LENGTH MEASURES

Sl. No.	Source	Length of Units		
		Danda*	Krosa**	Yojana
(1)	*Arthashastra*	1·7143 m *1·9286 m* (Preferred)	1·7143 km *1·9286 km* 3·4286 km *3·8571 km*	6·8571 km *7·7143 km* 13·7143 km *15·4286 km*
(2)	*Ganita Tilaka*	1·5 m	3 km	12 km
(3)	*Lalitavistara*	1·75 m	1·75 km	7 km
(4)	*Brahmanda Purana*	2 m	4 km	16 km
(5)	*Ganita-sara-Sangraha*	2 m	4 km	16 km
(6)	*Lilavati*	2 m	4 km	16 km
(7)	*Sukraniti*	2·143 m 2·743 m	3·429 km 1·714 km	— —

*Danda is also called dandaka, dhanu etc.
**Krosa also called goruta, gavyuti etc.

It will be noted from Table 3 that it is possible to derive on the basis of the literature examined earlier, as many as seven different values for the yojana and an equal number for the krosa.

Confusion about Yojana

The unit of yojana has caused considerable confusion in the ancient geographical and astronomical literature. The geographical confusion is obvious from Table 3. In astronomy, the yojana is employed to indicate long distances or dimensions like the diameter of the earth and the planets, the distances covered by them in their orbits and the space between them.

A survey of the astronomical literature shows that the circumference of the earth is taken as either approximately 3 300 yojana or 5,000 yojana. Opinion on the acceptance of any one of these values seems to be equally divided.

Aryabhatiyam[28], *Panchsiddhantika*[29], *Mahabhaskariya*[30], *Shisyadhivriddhida*[31], *Vateswarasiddhanta*[32], and *Siddhantadarpan*[33] recognise the value of 3 300 yojana.

The votaries of the 5000 yojana circumference are *Suryasiddhanta*[34], *Brahmasphutsiddhanta*[35], *Mahabhaskariya*[29], *Siddhantasekhara*[36], *Siddhantasiromani*[37], *Somasiddhanta*[38], *Shakalyokta*[38], and *Brahmasiddhantar*[38].

It appears somewhat surprising that a natural constant dimension like the circumference of the earth should also acquire two values. The circumference of the earth is approximately 40 000 kilometres. Assuming that the ancients somehow measured the

circumference of the earth more or less correctly, the yojana according to the first group of astronomers would be approximately 12·12 kilometres while in the second set it would be 8 kilometres. The 12 kilometre yojana is mentioned in the *Ganitatilaka* but the *Vateswarasiddhanta* assumes an angula of 8 yava and the yojana of 32,000 hasta. This should give the yojana of 16 kilometres ! Similar is the case with many of the other authors including Bhaskaracharya II.

The 8 kilometre yojana would be rather difficult to explain because it has been mentioned by many authors that the yojana consists of 32,000 hasta and the angula of 8 yava —thus giving the yojana of 16 kilometres.

So far no satisfactory explanation has been given for the difference in the two values of the yojana occurring in astronomical works. The problem requires considerable research if it is to be explained rationally. For our immediate geographical purposes, however, the values given in Table 3 should suffice.

The Gaz and the Double Hasta

Gover[39] and Balfour[25] record the tradition that although the hasta differed in different parts of India the relation between the gaz and the hasta was usually in the proportion of 7 : 12. We had occasion to refer in Part 1 of this article to a possible explanation of this phenomenon. Commercial hasta of *Arthashastra* consisted of 28 angula. Apparently the 48 angula (double aratni) also came into use, perhaps, in the post-*Arthashastra* period. The relation between these two is 28/48 = 7/12. The 28 angula hasta was then reduced to 24 and therefore, the aratni was reduced to 21 angula and the double aratni or gaz became 41 or 42 angula. We showed earlier that this was the basis of the Ilahi gaz.

What applies to one type of hasta should as well apply to others and, therefore, it may be instructive to evaluate the gaz derived from the various hasta units in the proportion of 7 : 12.

It is also possible that some of the hasta units may have been merely doubled and used for certain purposes. Table 4 records the various hasta and double hasta units as also the gaz units derived from them on the basis of the ratio of 7 : 12.

TABLE 4—HASTA, GAZ AND DOUBLE HASTA

Sl. No.	Hasta Unit		Gaz (7:12)		Double Hasta	
	Arthashastra	Post-Arthashastra	cm	inch	cm	inch
(1)	21 angula (37·5 cm)	18 angula	62·49	24·6	75	29·5
(2)	24 angula (42·86 cm)	—	73·65	29·0	85·72	33·7
(3)	—	21 angula (43·75 cm)	75·00	29·5	87·50	34·4
(4)	28 angula (50 cm)	24 angula (50 cm)	85·71	33·7	100	39·4
(5)	32 angula (57·14 cm)	—	97·95	38·6	114·28	45·0
(6)	54 angula (96·43 cm) (38·0 in)	—	165·3	65·1	192·86	75·9
(7)	—	46 angula (95·83 cm) (37·7 in.)	164·3	64·7	191·66	75·5

Area Measures

Those who have studied the economic conditions in ancient or medieval India have been astonished at the richness and variety and the consequent confusion in the measures of area used in the various regions and periods.

So far as South Indian area measures are concerned many of them appear to have their foundations in the *Arthashastra*. We have, however, to examine the *Arthashastra* area measures from a somewhat different angle if we have to understand their development in South India.

The *Arthashastra* nivartana is a square, each side of which has a length of 3 rajju, or 30 danda, or 120 or 240 Prajapatya hasta (*see* Part I). The area is thus 14 400 or 57 600 square hasta. Alternatively, the *side of the nivartana* is 12×10=120 hasta or 24×10=240 hasta. That means the nivartana is one hundred times the area units based or 12 or 24 hasta. This is an important South Indian tradtion. If we take the paridesa, the side is 80 or 160 hasta and the area 6 400 square hasta or 25 600 square hasta. Alternatively it is 100 times the area of a square of 8 or 16 hasta. The nivartana and paridesa are related to each other as 9:4 because the basic sides are 3 rajju and 2 rajju respectively.

The *Arthashastra*, however, prescribes other length units for measurement of areas for specialized purposes. Thus the 28 angula hasta is used for measuring pasture lands, the kishku of 42 angula is used for measuring ground for the encampment of army, for forts and palaces, while the 54 angula hasta is used in measuring timber forests. There are no instructions about how these length measures should be used for area measurements. We may, therefore, examine them on the same principles as used earlier for deriving the area of the nivartana and paridesa. Table 5 lists the magnitudes of the various area units derived from the hasta units defined in the *Arthashastra*.

TABLE 5—ARTHASHASTRA AREA MEASURES

Basis: (1) side of nivartana=120 or 240 hasta — Nivartana=14,400 or 57,600 square hasta
(2) side of paridesa=80 or 160 hasta — Paridesa=6400 or 25600 square hasta

Sl. No.	Basic Unit	Nivartana		Paridesa	
		m²	yd²	m²	yd²
(1)	Prajapatya hasta	2,645·3	3,163·7	1,175·7	1,406·1
	(24 angula i.e. 42·86 cm, for general use)	10,581·0	12,654·8	4,702·7	5,624·3
(2)	Hasta	3,600	4,305·6	1,600	1,913·6
	(28 angula i.e. 50 cm, for pasture lands)	14,400	17,222·3	6,400	7,654·3
(3)	Kishku	8,100	9,687·5 (2 acres)	3,600	4,305·6
	(42 angula i.e. 75 cm, for army, forts, palaces)	32,400	38,750 (8 acres)	14,400	17,222·3 (3·55 acres)
(4)	Hasta	13,390	16,014·6	5,951·2	7,117·6
	(54 angula i.e. 96·43 cm, for timber forests)	53,561	64,058·1	23,804·8	28,470·3

Table 5 helps us in understanding many South Indian traditions in area measures. It does not, however, cover the whole range. Other methods of calculation were also used which will be explained in Part 3 and Part 4.

It will be noted that Table 5 also covers the area units mentioned in *Sukraniti*, *Ganita Tilaka*, etc. Another point to be noted is that the word nivartana was also used for the paridesa unit as is evident from *Sukraniti*.

In Part 3, we shall examine the various South Indian length and area measures that were commonly used and an attempt made to explain them in the light of the traditions discussed in Part 1 and Part 2 of this article.

REFERENCES

(*Continued from Part 1*)

(17) ब्रह्माण्डमहापुराण (Venkateswar Press, Bombay), 1935.

(18) *Ganita Tilaka by Sripati*, Edited by Kapadia, H. R., (Oriental Institute, Baroda), 1937.

(19) (*a*) *Lalita Vistar*—Translated into French by Foucaux, (Ernest Leroux, Paris), 1884.

(*b*) ललित विस्तर (Sanskrit Text), Edited by Vaidya P. L., (Mithila Institute of Post-graduate Studies and Research in Sanskrit Learning, Darbhanga), 1958.

(20) *The Ganita-Sara-Sangraha of Mahavira—Carya*-Sanskrit text and English Translation by Rangacarya, M., (Government of Madras), 1912 .

(21) *Bhaskaracharya's Lilavati* (Sanskrit Text and Marathi Translation by Khanapurkar V. P., (H. V. Sathe, Poona), 1897.

(22) (*a*) *Sukraniti*—Translated by Basu B. D., (Sudhindranath Vasu, Allahabad), 1914.

(*b*) शुक्र नीतिसार (Sanskrit Text), Edited by Jivananda Vidyasagara.

(*c*) शुक्रनीति—Sanskrit Text and Hindi Translation by Mihirachandra, (Shri Venkateswar Press) Samvat 1982.

(23) Barnett, Lionel D, *Antiquities of India*, (Philip Lee Warner, London), 1913.

(24) *Ain-i-Akbari*—Translated by Blochmann, H., Second Edition, (Royal Asiatic Society of Bengal, Calcutta), 1927.

(25) Balfour, Edward, *The Cyclopaedia of India and of Eastern and Southern Asia*, 3 Vols, (Bernard Quaritch, London), 1885.

(26) Moreland, W. H., *India at the Death of Akbar*, (Atma Ram & Son, Delhi), 1962.

(27) Cracroft, W., *Journal of the Asiatic Society of Bengal*, Vol, 3, p 360, 1834.

(28) (*a*) *The Aryabhatiyam* Translated by Sen Gupta, P. C., (Journal of the Department of Letters, University of Calcutta, vol 16, 1927)

(28) (*b*) श्रीमदार्यभटीयम् (Sanskrit Text) Edited by Kern H., (E. J. Brill, Leiden), 1874.

(29) Panch-Siddhantika (Text and Translation by Thibeau, G. and Dvivedi, Sudhakar (Benares), 1889.

(30) Maha-Bhaskariya—(Edited and Translated by Shukla K. S.) (Department of Mathematics and Astronomy, Lucknow University, Lucknow), 1960.

(31) *Shisyadhivridhida of Lulla*, Edited by Dvivedi, Sudhakar (Benares), 1886.

(32) *Vateshwar Siddhanta*, Edited and Translated into Hindi by Sharma, R. P. & Misra M. (Indian Institute of Astronomical & Sanskrit Research, New Delhi), 1962.

(33) *Siddhanta Darpanam by Nilakantha Somayajin*—Edited and Translated by Sarma, K. V., (The Adyar Library and Research Centre, Madras).

(34) (*a*) *Surya-Siddhanta*—Translated by Burgess, Ebenezer (University of Calcutta, Calcutta), 1935.

(34) (*b*) सूर्यसिद्धान्तः (Sanskrit Text) Edited by Kapileswara Chaudhary (Jayakrishna Das Haridas Gupta, Chowkhamba Sanskrit Series, Benares), 1946.

(35) ब्रह्मस्फुटसिद्धान्त (ब्रह्मगुप्त) Edited by Sudhakar Dwivedi, Benares.

(36) *The Siddhanta—Sekhara of Sripati*—Edited by Babuaji Misra (Srikrishna Misra Maithila) (University of Calcutta, Calcutta) Part 1, 1932; Part 2, 1947.

(37) सिद्धान्तशिरोमणि (भास्कराचार्य 2) Edited and Translated into Hindi by Dwivedi, G. P., (Newul Kishore Press, Lucknow), 1926.

(38) Dixit, S. B. *Bharatiya Jyotisshastra* (Marathi) Second Edition (A. V. Patwardhan, Poona), 1931.

(39) Gover, Charles E.,—*Indian Weights and Measures, Their Condition and Remedy* (Male Orphan Asylum, Madras), 1865.

Working Standard Balances : Part 4—Knife-edges

B. R. DHURANDHAR

Saple's Scale Manufacturing Company (P) Ltd., Bombay

IN the first three Parts* of this series of articles the guiding factors in design, the general specification and the beam design of working standard balances were considered in detail. It is now intended to discuss the various factors influencing the knife-edge, its material and design.

Knife-edge in a Good Beam

The moment of a force can be determined correctly if the distance between the point of application of the force and the point round which the force acts can be determined accurately. This will depend upon how fine these points can be drawn or made. The distance between the two pinpoints will not alter if the pinpoints are stationary or if they move in such a way that their focii are two parallel straight lines. A fine knife-edge can be looked upon as a fine line. Two parallel knife-edges would, therefore, form a long series of points which are equidistant from each other. A force acting through the edge can, therefore, be considered as a load acting through innumerable points which the edge is made of. The moments of force acting through one edge round the other parallel edge could, therefore, be determined accurately. These moments will not vary even if the application of load or force is shifted from one end of the edge to the other.

The beam of a working standard balance is a lever of the first order. So a comparison of weights is necessarily a comparison of moments. A good beam, therefore, is one in which moments can be compared accurately. The placement or fixing of well-made and finished knife-edges into the beam is, therefore, of the utmost importance in a good beam.

What is a Good Knife-edge ?

What do we mean by a well-made knife-edge and what is its proper placement in a beam?

The following aspects of a knife-edge are now considered important:

(1) Material.

(2) Shape i.e. cross-section.

(3) Size i.e. length at the base.

(4) Edge proper.

(5) Method of fixing.

---

*(1) Working Standard Balances : Part 1—Guiding Factors in Design—*Metric Measures*, Vol. 4, No. 3, pp 3—6, 1961.

(2) Working Standard Balances : Part 2—General Specifications—*Metric Measures*, Vol. 5, No. 5, pp 3—8, 1962.

(3) Working Standard Balances : Part 3—Beam Design—*Metric Measures*, Vol. 6, No. 4, pp 10—14, 1963.

The choice of the appropriate material depends upon the following qualities in it:

(1) Retention of the edge over a long period

(2) Resistance to crushing loads

(3) Resistance to abrasion

(4) Resistance to corrosion

(5) Resistance to shear stresses, in certain cases.

The edge will retain its sharpness and efficiency if the material is hard enough to bear the specified load. It must be borne in mind that the intensity of the load carried by the edges is enormous. It can, however, be lessened by making the edges sufficiently long. The material to be selected should, therefore, be such that it is naturally hard or can be hardened by processing. A material which satisfies the first requirement is natural stones like agate or synthetic materials like carbides or corrundum, while material of the latter type is steel.

All the materials have been successfully used depending upon the loads they have to bear.

Cross-section and Size

The edge would not crush under load if it is sufficiently long and its base is broad enough to distribute the load evenly. The length and the cross-section of the edge have to be so chosen that for the size of the beam they are not too large. Generally, the length of the central knife-edge is 1/12 and of the end edges 1/24 of the length of the beam.

Cross-sections with base angle of 60° are common but base angles smaller than 60° have also been used where the load is to be distributed less intensely. The edge angle is usually formed out of two facets of the edge enclosing a maximum angle of nearly 120°. This facet angle is related to the shape of the bearings of the fulcrum and those fixed in pan suspensions. V—grooved bearings necessitate the use of smaller facet angles while flat planes allow larger facet angles to be used. The larger the angle of the facets the better would the edge retain its shape under the impact of the load through the bearings.

This is again limited by the deflection of the beam. In certain cases like the self-indicating weighing instruments where the deflection of the beam has to be considerable and the edge is working in a V—grooved bearing the facet angles are reduced to even 30°.

The above discussion indicates what a good knife should be. To achieve this in practice is difficult, and demands extreme precision of work and the use of high precision testing instruments.

The Edge

The knife-edge, as stated earlier, is formed out of two facets on either side. These are two geometrically perfect planes intersecting to form a good edge. The manufacturer, therefore, grinds the facets so as to form two perfect planes. The sharpness and perfection would naturally depend upon the grinding surfaces used. The grinding surfaces have to be rigorously plane throughout the grinding operation.

Equally great care has to be taken while polishing the facets. Polishing is necessary to get a smooth edge which thus acquires a very large number of points of contact throughout its length. More the points of contact, less is the intensity of load on the points of contact of the edge and better is the sharpness retention.

Method of Fixing

The performance of the beam will depend not only upon the quality of the edge and the

care taken to make it, but also on whether it has been properly fitted in the beam scale. Not only should the knife-edges be coplaner and parallel to each other, but also lie in a particular horizontal plane of the beam. Moreover, the side edges should be equidistant on both sides of the central knife-edge. Lastly, their fitting should be such that they are free from mechanical defects.

Defective mechanical fitting is one in which the edge is either loosely fitted or fitted too tightly, thus developing stresses in the edge itself. A non-defective fitting would be one in which the edge is perfectly in contact at its bottom surface and held firmly without stressing it.

There are many methods of achieving this depending on how the particular beam scale is likely to be used. The commonest method is fitting the edges directly in the beam or fitting them by means of a number of screws.

In the case of working standard balances, it is desirable to fit the edges directly into the beams themselves, as these balances are often moved from place to place. Knife-edges in heavier capacity beam scales are likely to get loose in transit. Direct fitting, however, limits precision and cannot be used where higher sensitivity and accuracy are needed. It has, therefore, to be abandoned when balances of precision higher than the working standard balances are to be made. So also the delicate beam of a small capacity balance does not permit direct fitting of knife-edges. In small capacity precision balances the edges are often not directly held by means of screws but are first embedded or sealed in sockets by means of lac and the sockets are then fitted by means of screws.

The performance of a good working standard balance, it should now be clear, depends largely on the quality of the raw materials used for the knife-edge, the method of fitting the knife-edges and the ability of the edge to maintain its sharpness over long periods of time.

In Part 5 we shall discuss how other accessories of the working standard balance are designed.

For Defence Strength
For Strength Planned
Development

Ten Years of Weights & Measures Division in NPL

The National Physical Laboratory of India has recently compiled a brief account of the work of the Division of Weights and Measures during the 10-year period April 1953—March 1963.

The report which runs into 16 pages makes very interesting reading.

Creation of the Division

The planning and development of a chain of national laboratories in India under the Council of Scientific and Industrial Research goes back to the beginning of the Second World War, when the gross inadequacy of our scientific and technological organisations was keenly felt. The National Physical Laboratory of India was the first to be set up in 1947, in view of its importance to the growing industrial economy of the country. The laboratory was shifted to its new building early in 1950. The Weights and Measures Division was one of the main divisions organised in the laboratory. This Division was planned to be the custodian of the national prototype standards of length and mass, to be responsible for installing suitable apparatus and equipment for supplying sub-standards to other testing institutions, and to undertake for science and industry all work involving precise measurement of length and mass.

Functions

The functions assigned to the Weights and Measures Division are:

(1) to maintain standards of length, mass and time;

(2) to have equipment for the comparison of scales, surveying tapes etc. and for accurate comparison of the mass of weights of different denominations;

(3) to supply sub-standards of length and mass to other testing institutions;

(4) to equip for the measurement of density and gravity;

(5) to equip itself for testing of gauges, volumetric glassware, hydrometers, screw-threads, fine instruments and mechanical meters;

(6) to maintain a primary standard barometer;

(7) to install dividing machines and ruling lathes;

(8) to set up necessary equipment for carrying out periodical intercomparisons of the reference and the derived standards under continually improving conditions; and

(9) to develop and test new types of apparatus which will facilitate different types of measurements with increasing accuracy.

The work of the Division was organised in three sections—the Mass Section, Length Section and Horology Section. Priority was given to the development of the Mass Section which was of immediate importance to scientific institutions and industry. In addition to these Sections, a small Precision shop was also set up.

Mass Section

The Division started work with only a few balances and a set of uncertified analytical

weights. It is now equipped to carry out tests on weights from 50 kg to fractions of a milligram, volumetric glassware such as burettes, pipettes, graduated flasks, cylinders, butyrometers and other specialised glassware items, capacity measures, hydrometers, viscometers, balances of various capacitites and for the measurement of density, viscosity etc.

Length Section

Starting from scratch, the Length Section is now well-equipped for carrying out precision physical and engineering measurements such as calibration of precision linear measures, testing of different types of scientific, industrial and engineering measuring instruments; mathematical, drawing and surveying instruments; different types of engineering gauges; assessment of surface finish, surface straightness etc.; measurement of metric and inch slip gauges by means of mechanical comparators or with gauge interferometer; measurements on screw threads, gears, bearings, machine tools, hand tools and other small tools etc., test sieves, wire or silk cloth for test sieves; dimensional tests on various mechanical and electrical industrial, or household appliances such as bicycle components, sewing machine components, oil stoves, electrical motors, switches, cables, conductors, plugs and sockets, household irons etc.

Horology Section

This Section is equipped for carrying out craftsmanship test and other tests on watches, stop-watches, clocks and clockwork mechanisms for instruments as well as for testing various component parts of watches and clocks. Work on the setting up of a number of 'quartz crystal' clocks and 'Ammonia clock' was also carried out.

Precision Shop

The Precision Shop now has a linear dividing machine, circular dividing machine, a small jig borer, a pantograph, a rhodium plating unit, lapping equipment and several furnaces for hardening and tempering of gauges.

Maintenance of Standards

From the point of view of metrology in India, the NPL has been holding important responsibilities. Under the provision of the Standards of Weights and Measures Act, 1956, the National Physical Laboratory is the authority which will keep the National Standards of Weights and Measures as certified by the International Bureau of Weights and Measures.

In the enforcement of weights and measures in India, the Weights and Measures Division was required to adjust a large number of standard weights and measures which were then supplied to the Weights and Measures (Enforcement) Departments all over the country.

The Division is equipped with an SIP high precision comparator for linear standards and an NPL Hilger gauge interferometer for the absolute measurement of end standards of length. Several Krypton-86 lamps were presented by the President of the Physikalisch Technische Bundesanstalt.

The Division also possesses several other essential items of equipment for standard works, namely, a complete range of precision mass balances, a hydrostatic balance for the calibration of reference hydrometers, master viscometers and other necessary equipment for viscometry, line and end standards of length, standard angle gauges, polygons etc.

Developmental Work

Among specific items, the following may be mentioned :

1 kg special Balance

The designing and construction of a 1 kg very high precision balance with pan-interchange mechanism has been taken in hand.

The design of this balance, which will be used for the intercomparison of the laboratory standards against the National Prototype Kilogramme is broadly based on the balance constructed by the NPL, Teddington, for the same purpose.

Primary Standard Barometer

A primary standard barometer is being designed and would be ready within the next year or so.

Standard Weights

The construction of standard weights in brass and bronze, plated with rhodium, was taken up as a regular project with a view to derive the higher denominations of standards of mass. A series of weights are now being standardised against the standard weights.

Plane Surfaces

Highly accurate plane surfaces were expected to be produced for developing good quality surface plates and to make slip gauges.

Knife-edges etc.

A project for developing the techniques for the production of good quality agate and steel knife-edges and bearing planes for use in precision balances has been in operation for about a year.

A special gadget for testing the life of knife-edges of precision balances of different capacities under loaded condition is being set up with a view to assess the suitability of different types of locally available agate for making knife-edges and bearing planes. Large quantities of agate are being exported but little is known about the varieties suitable for making knife-edges. The manufacturers of balances are never sure of the quality of agate used by them.

Linear and Circular Scales

A project for the production of high precision linear and circular scales, precision graticules and glass scales was started some time back. Accurate circular scales on glass particularly for use in theodolites and different types of graticules for use in microscopes are made by specialised processes. This requires some amount of investigational work. This has been taken in hand. It is proposed to pass on the processes to industry after working them out successfully.

Special Projects

Two important projects were undertaken at the instance of the Ministry of Commerce and Industry for the Weights and Measures Enforcement Departments. These were designing and construction of :

(*i*) a machine for marking glassware by means of a jet of sand ; and

(*ii*) a comparator for the intercomparison of line standards of length.

The Weights and Measures Division was asked to evolve simple designs so that these items could be manufactured locally at reasonable cost and without importing any components. Prototypes of the length comparator and the glass marking machine have since been made and passed on to the authorities concerned. These two projects will result in a saving of half a crore of rupees in foreign exchange.

Popularization of Metric Weights

The NPL also helped in popularising metric weights by working out suitable designs for commercial weights and making sets for display in States and Union Territories. Among other projects, may be mentioned the construction of a double walled double door glazed chamber for testing balances at different temperatures. The testing can be carried

out from outside the chamber by manipulating the controls.

Technical Assistance to Industry

Weights and Chemical Balances

Firms producing weights and analytical balances for scientific purposes were assisted in production of weights and balances having the desired accuracy for scientific work. Sets of balances were tested in the laboratory, alterations suggested and the process repeated until satisfactory performance was obtained

Manufacture of Commercial Grade Weights

The manufacturers of commercial weights in India were assisted by providing them with adjusted sets of commercial weights for checking masses of weights produced by them. Similar assistance was also given regarding capacity measures.

Standard Weights and Capacity Measures

Designs of reference, secondary and working standard weights for use by the States' Enforcement Departments were worked out in collaboration with the India Government Mint, at Bombay and others. Twenty sets of reference standard weights were made by the Mint and were then stabilized and adjusted at the NPL within the prescribed limits of tolerance and issued to the States. Sets of secondary standard weights and capacity measures were also adjusted and supplied to the States with certificates.

Balances for Weights and Measures Departments

The Weights and Measures Enforcement Departments require accurate balances of capacities ranging from 50 kg to 2 g. To assist in their production, specifications were drawn up in consultation with the ISI, the Standing Metric Committee and others concerned and manufacturers of balances in the country were asked to prepare sample sets of balances and send them to the NPL for critical examination. Difficulties in design and faults in fabrication were set right and new sets of balances tested again until the manufacturers sent balances of the required quality. As a result of the work, an industry producing the complete range of balances has now come into being in the country. Designs for reference and secondary standard balances are now being considered and specifications are being drawn.

Training Facilities for the Industry

The Division has also assisted the industry in imparting technical training to their representatives in various fields falling in the purview of the Division.

Training of Inspectors

Besides co-operating in the work of the various Committees and Sub-committees set up by the Indian Standards Institution and the Ministry of Commerce and Industry, the NPL also undertook the major project of training of Inspectors of Weights and Measures intensively for one week in the testing of balances, weights, capacity measures and linear measures. This training included theoretical as well as practical aspects of testing, besides fully instructing the Inspectors in adjustments and the like of the knife-edges of the balances. In a Programme lasting for about 14 months, with a break of three months, 256 officers including 11 Controllers took the training.

Future Expansion

A new wing is to be added to the existing laboratory building for the use of the Weights and Measures Division. All the work relating to standards will be housed in this wing which will have several special features such as isolated floors, close temperature control in most

of the rooms, some draught-free rooms for balances and other special requirements for the electrical and the optical standards. It will also have a special room which will house a 50 metre tape measuring equipment for the calibration of geodetic tapes.

The procurement of several items of equipment such as 'Talyrond' roundness measuring instrument, 50 tonne dead weight tester, equipment for pneumatic gauging etc. which has been deferred for the time being will also be taken up.

When more space becomes available, the Division can expand its activities particularly in respect of developmental testing for the industry.

Change-over in Industries

THE Eighth Indian Standards Convention was held at Ahmedabad from 22 December to 28 December 1963.

A Session (S-5) held on Monday, 23 December 1963, was completely devoted to *Progress of Change-over to Metric System in Industrial Production.* In all seven papers listed below were considered. The resulting discussion was interesting.

S-5/1	Review of Change-over to Metric System in Tata Iron and Steel Company	Dr. A. V. Sukhatme
S-5/2	Problems in the Change-over to Metric System in Heavy Electrical Industry	B. S. Bhagowalia
S-5/3	Problems in Change-over to Metric System in Automobile Production.	N. V. Meswani
S-5/4	Metric Change-over in Building Industry.	J. K. Varshneya
S-5/5	Metric Building Bricks	J. Walter
S-5/6	Problems of Introducing Metric System in Cotton Textile Industry.	M. R. Ramachandran
S-5/7	The Change-over to Metric Fasteners in India	S. K. Maini

Chairman's Opening Remarks

Shri T. Swaminathan, Secretary to the Government of India, Departments of Supplies and Technical Development, New Delhi, presided over the Session.

Speaking about the introduction of metric system in India, the Chairman stated that the move was initiated by India long back and it was welcomed by all. Since people are accustomed to a particular way of working and as different standards of weights and measures had been in vogue, the problem was quite difficult. In spite of it, standard specifications have been laid down for a variety of products and definite progress made towards achieving the goal of change-over to metric measurements.

He pointed out that the adoption of the metric system in the country was an opportunity as well as a challenge. It was an

opportunity as it helped in national integration through the adoption of uniform weights and measures and trading practices all over the country and also enabled us to step up our export trade with other countries, as 80 percent of the countries use the metric system. It was a challenge to engineers and others because the industries had now to solve a large number of problems of a fundamental nature in a rather limited period of time. He referred to the considerable rethinking undertaken in countries using the FPS system where production for export was required to be made both in the foot-pound and the metric systems.

In the context of the European Common Market, the Chairman observed that if India was to trade with these Common Market countries, she would naturally have to change-over as early as possible, so as to be able to walk side by side with other countries who were becoming more and more unified. He mentioned the statement issued by the British Standards Institution (BSI) on the adoption of the metric system in the UK. He said that it was a matter of pride for all of us that the BSI was now looking to India and the ISI for guidance and advice because India had already gone ahead with the adoption of metric system. Even then, if we have to catch up with the other 80 percent countries who use the metric system, we had to do a lot of work which remained to be done. Much of it has to be achieved by 1966, the target date for the full adoption of the metric system. It was thus necessary that the pace of the change-over should now be accelerated so that the industries do not find themselves in an awkward position with regard to raw materials, instruments, machines and other accessories.

Plan of Discussion

The papers were discussed in three groups, namely : Engineering Group, Civil Engineering Group and Textiles Group. The points that emerged from discussions were as follows:

(1) Phased Programme

The stage had now been set in India for a complete change-over to the metric system in industry. We have now to adapt ourselves psychologically to the new change. It is necessary for financial as well as technical reasons that we should work out a realistic programme for phasing the change-over. The Indian Standards Institution had now provided almost all the specifications for raw materials and other products required by the industry for the change-over of their designs, equipment and production to the metric system. It was now necessary that the industries should take steps to order raw materials to metric specifications and plan a programme for changing their production to the metric system. If these steps are not taken it is likely that many industries may create difficulties for themselves. The industries which have been procuring their raw materials and equipment in terms of the FPS system had apparently not given much thought to their requirements in the future. A large number of basic raw materials were now being made available in progressively larger quantities in the metric system.

(2) Training of Engineers

A complaint was also made that the engineers who are coming out of the universities had little knowledge of the metric system. It was, however, pointed out that a programme of change-over in engineering education had already been undertaken. According to this programme the first four year-classes in technical colleges had already changed over to metric teaching and the fifth-year classes were expected to go over to metric teaching from 1964-65. Thus within the next year or two the engineers who pass out will be fully conversant with the metric practices.

(3) Collaboration

There was considerable discussion about the role of collaboration and its effect on the change-over. It was pointed out that many production units had been started in collaboration with countries using the FPS system. The designs adopted by these foreign firms had been used for production. For such collaborating organisations, therefore, it was necessary that raw materials according to the old system should be available. The Chairman and many others pointed out that both the UK and USA were willing to supply equipment in the metric system, provided the partner country asked for it. They were already giving such equipment not only to the West European countries but also to India whenever asked for specifically. The problem of collaboration, said the Chairman, needed considerable attention. At the very outset when collaboration was considered, adequate care should be taken to ensure that metric equipment was obtained as also that products be designed to metric specifications. In cases where collaboration had already been entered into, the firms should go over to the metric design on their own at the end of the collaboration period. This should be possible, he said, as the producers would have obtained enough know-how during the period collaboration was effective. He pointed out that if even after this, FPS dimensioned products continued to be produced or collaborations entered into, Government should refuse foreign exchange for such collaborations. What was required was that we should adopt international practices.

(4) Metric Bricks

So far as civil engineering was concerned, it was found that the main problem was the manufacture and supply of metric bricks as standardised by the Indian Standards Institution. Certain difficulties in the table moulding of metric bricks were pointed out. It was agreed that these difficulties could be overcome by *slight modifications in the* mould and did not require a wholesale change in the specification. It was stressed that a beginning should be made with the use of metric bricks because most of the problems connected with their production, stability etc. had now been overcome. It was now a question of supply and use.

(5) French Count

The decision of the cotton textile industry to adopt the French count in preference to the tex was also discussed thoroughly. It was explained that the decision was taken after consultation with the industry and particularly for the benefit of handloom weavers. The general feeling, however, was that this decision needed reconsideration at the appropriate level in the Government.

Summing Up

Summing up, the Chairman said that the progress of the adoption of metric system in industrial production was not fast enough. A determined effort was now necessary if the industry was not to be caught on the wrong foot so far as raw materials and end products were concerned. The expenditure involved, it was pointed out again and again during the discussions, was not at all heavy. It was necessary to press on with the compulsions and make our engineers start thinking in terms of the metric system and using metric products.

With a vote of thanks to the Chair, the session concluded at about 12·30 p.m.

*A Move To Metric Has Wide Support**

AN early decision on the adoption by British industry of metric weights and measures is called for in the recent report of the BSI on *British Industry and the Metric System.*

Metric System

The report, based on discussions over the past year within BSI committees which are responsible for standards policy in 50 major industries, shows that there is now strong support for a speedy move to the metric system.

'There emerges' says the report 'a substantial majority view that changes are inevitable and that they should be directed towards the introduction of the metric system as the primary system of weights and measures in the United Kingdom within the shortest practicable period.'

Over a year ago, in view of the growing volume of opinion which advocated the adoption of the metric system, BSI issued a pamphlet (*Change to the metric system* ?) (see *Metric Measures*, Sep. 62, pp. 17-23—*Ed.*) reviewing the considerations involved for industry, the action which would have to be taken if it were decided to go metric, and suggesting a phased programme for the change.

Since then committees in BSI representative of manufacturers and other interested bodies in a wide range of industries have considered this review and the main questions which emerged from it—whether particular industries wished to change to the metric system, how long it would take, and whether it should be dependent on a parallel move by the United States or the Commonwealth, as well as detailed questions on the metric standards to be used.

The positive view now reported is, with only a few exceptions, not conditional on similar action by the United States or the Commonwealth.

Export Advantages

The BSI's high-level Export Panel favours a change to metric because of the increasing use of the metric system in the more rapidly expanding world markets, and in view of Britain's growing trade with Europe.

The report recognizes that the time required to make a change will vary from industry to industry and that certain of them—notably petroleum equipment, aircraft and automobiles—must remain basically on the inch/lb system of standards until a change is made in the parallel industries of the United States. In some other parts of the engineering industry the move would inevitably be protracted with dual production, to inch and metric standards, to cater for special customers and for spares and replacements over a considerable period. Close co-ordination between industries using one another's products would be required, the report points out.

BSI as Britain's national standards organization has to look at the question of a change

*From *BSI News* —November 1963, p 13.

primarily in terms of the dimensional standards which provide industry with its basic production and purchasing pattern, and the report indicates the general lines on which BSI's work would have to proceed. Though many other aspects of a change to metric are important, the dimensional standards of the engineering industries are unquestionably the key factor and it is changes in them that would be the major cause of the heavy costs which a change to the metric system would involve.

Changes made to standards (which in the main are voluntary in Britain) could be quickly reflected—even without government action—in trade and commerce and in daily life. Use of the metric system is permitted by law in this country, except for sale of a limited number of goods in specific weights. Clearly, however, a government pronouncement would decisively influence the pace of any change and the effectiveness of action throughout the economy.

The report underlines the need for systematic education in the metric system. The introduction of decimal coinage, though this is an entirely separate issue, would be a move towards the same decimal thinking inherent in the metric system.

Copies of the report have gone to the government and to a wide range of industrial, trade, technical and professional organizations.

CHANGE TO METRIC

(The following letter was published in the *BSI News* December 1963, p 22. It is hoped that readers of *Metric Measures* will find it of interest. —*Editor*)

Sir,—The report by the British Standards Institution, *British Industry and the Metric System*,)* is a timely document of fairly noncommittal nature which reports a noticeable, but not pronounced, inclination towards the metric system. Perhaps it is regarded as an interim statement, a Phase 2 to the May, 1962 document—*Change to the Metric System* ? The wisdom of this careful approach by the British Standards Institution is unquestionable, but something more must come from the leading organizations in industry, trade and H.M. Government. As stated in the opening paragraphs of the report, it requires a decision by those concerned.

I venture to suggest that it is not possible to make a gradual decision to change to the metric system. The inch system can fade gradually and the metric system can take its place at a speed to be regulated; but, if a change is to be made, the decision must be taken at a point in time. Thus two decisions are required :

(*a*) Should Britain change to metric ?

(*b*) At what point in time should metric become the primary system ?

It seems to me that there are two approaches to question (a). Without doubt some manufacturing interests and a large share of the defence programme are so closely linked with the United States and Canada that the Imperial system must remain in use for so

*PD 5069.

long as America and Canada remain wedded to inches and pounds. It is equally certain that for life and vigour in the export market Britain must export and service in metric units. It would be vastly uneconomic for Britain to manufacture in two sets of units, and even worse to be schizophrenic in daily thought and action.

It therefore becomes vital that decisions should be made as to our future primary system, with free option to adopt, adapt or ignore as wisdom or whimsy may indicate. Given the decision, I have no doubt that time would find most people had come to accept it.

Unless and until a decision is made there are those of us serving in national and international work who are being torn apart. On the one hand increased participation in work between America, Britain and Canada is being advocated and on the other hand the same people, on the same subjects, are participating in ISO (International Organisation for Standardization) and IEC (International Electrotechnical Commission) work, and whispers of 'Perfidious Albion' pervade our best efforts.

It may be as difficult to provide an answer for question (b) as for (a), but its effect could have a mellowing influence on (a). Given a sufficient interval in which to brace ourselves (and perhaps to let off steam), the operative date for any change of primary system would come to be accepted with little more unfavourable impact than that occasioned by the exponents of a flat earth theory.

Never let it be said that I sit on the fence—

(*a*) Yes;

(*b*) 1 January, 1970 but, hedging a little, give official recognition to both systems, from January, 1965.

A. H. L. TRAPNELL

Kingsdown
Box, Wilts

BUY ONLY WHEN YOU MUST
KEEP PRICES DOWN

Simple Area & Volume Conversions

M. L. KALSI
Directorate of Weights & Measures,
Ministry of International Trade
New Delhi

SOME easy methods of conversion of British length units to metric have been published in *Metric Measures*, September 1963, pp. 13—15. Conversion of area and capacity units is now taken up.

Area

(1) **Square metres to square yards**

Formula : Multiply the number of square metres (m^2) by 6/5 and subtract 1/10 of the number of square metres divided by 25. Results correct to two decimal places.

Example : Convert 305 m^2 into square yards :

$$305 m^2 = 305 \times 6/5 - \frac{305 \times 0 \cdot 1}{25}$$
$$= 366 - 1 \cdot 22$$
$$= 364 \cdot 78 \text{ yd}^2.$$

(2) **Square yards to square metres**

Formula : Multiply the number of square yards by 5/6 and add 0·07 for every square metre divided by 25. Results correct to two decimal places.

Example : Convert 312 yd^2 into m^2

$$312 \text{ yd}^2 = 312 \times 5/6 + \frac{312 \times 0 \cdot 07}{25}$$
$$= 260 + 0 \cdot 87$$
$$= 260 \cdot 87 \text{ m}^2$$

(3) **Acres to hectares**

Formula : Multiply the number of acres by 5/12 and subtract 6/5 of the number of acres divided by 100. Results correct to two decimal places.

Example : Convert 180 acres into hectares.

$$180 \text{ acres} = 180 \times 5/12 - 180 \times 6/5 \times 1/100$$
$$= 75 - 2 \cdot 16$$
$$= 72 \cdot 84 \text{ ha}$$

(4) **Hectares to acres**

Formula : Multiply the number of hectares by 12/5 and add the number of hectares divided by 14. Results up to 17 hectares correct to two decimal places. After 17 hectares subtract 0·01 for every additional 21 hectares from the above process as under :

			Subtract
18	—	38 ha	0·01
39	—	59 ha	0·02

and so on.

Examples : Convert 8 ha and 98 ha into acres.

(*a*) 8 hectares
$$= 8 \times 12/5 + 8/14$$
$$= 96/5 + 0 \cdot 57$$
$$= 19 \cdot 20 + 0 \cdot 57$$
$$= 19 \cdot 77 \text{ acres.}$$

(*b*) 98 hectares
$$= 98 \times 12/5 + 98/14 - 0 \cdot 04.$$
$$= 1176/5 + 7 \cdot 00 - 0 \cdot 04$$
$$= 235 \cdot 20 + 7 \cdot 00 - 0 \cdot 04$$
$$= 242 \cdot 20 - 0 \cdot 04$$
$$= 242 \cdot 16 \text{ acres,}$$

Capacity and Volume

(5) Gallons (Imp.) to litres

Formula : Multiply the number of gallons by 9/2 and add 4·6 times the number of gallons divided by 100. Results correct to two decimal places.

Example : Convert 109 gallons into litres.

109 gallons = 109×9/2+109×4·6/100
= 981/2+501·4/100
= 490·5+5·014
= 495·51 litres.

(6) Litres to gallons (Imp.) and pints

Formula : Multiply the number of litres by 2/9 and subtract hundredth part of this product from itself. Results correct to two decimal places.

To convert the decimal fraction into pints multiply it by 8 and divide by 100.

Example : Convert 109 l into gallons and pints.

109 litres = 109×2/9—109×2/9× 1/100.
=218/9—218/900
=24·22—0·24
=23·98 gallons
=23+98×8/100 pints
=23 gallons and 7-21/25 pints.

(7) Liquid seers to litres

Formula : Multiply the number of liquid seers by 15/16. Results correct to two decimal places.

Example : Convert 100 liquid seers into litres.

100 liquid seers =100×15/16=375/4
=93·75 litres.

(8) Litres to Liquid Seers

Formula : Multiply the number of litres by 16/15. Results correct to two decimal places.

Example : Convert 90 l into liquid seers.

90 litres=90×16/15
=96 liquid seers.

(9) Cubic feet to cubic metres

Formula : Multiply the number of cu ft by 3 and divide by 100. This gives result up to 2 cu ft. Above 2 cu ft multiply the number of cu ft by 3, subtract 1/6 of the number of cu ft and divide the whole by 100.

Note : When dividing by 6, take only the whole number. Above 200 cu ft subtract further 1/100th part of cu ft from the above result. Results correct to one place of decimal.

Examples : Convert 298 cu ft & 900 cu ft.

(*a*) 98 cu ft=(98×3—98/6)/100.

$$= \frac{294-16}{100}$$

=278/100=2·78 m^3

(*b*) 900 cu ft=(900×3—900/6—1)× 1/100
=(2700—150—1)×1/100
=(2700—151)×1/100
=2549/100=25·49 m^3

(10) Cubic yards to cubic metres

Formula : Multiply the number of cubic yards by 3/4 and add 0·15 for every cubic yard and divide by ten up to 10 cu yd. After 10 cu yd subtract 0·01 for every 20 additional cubic yd

i.e. from 11 to 30 subtract 0·01
31 to 50 subtract 0·02
and so on.

Examples : Convert 10 cu yd and 60 cu yd into cubic metres.

(*a*) 10 cu yd$=10\times3/4+10\times0{\cdot}15/10$
$=30/4+0{\cdot}15$
$=7{\cdot}50+0{\cdot}15$
$=7{\cdot}65$ m^3

(*b*) 60 cu yd$=60\times3/4+60\times0{\cdot}15/10-0{\cdot}03$
$=45+0{\cdot}90-0{\cdot}03$
$=45{\cdot}90-0{\cdot}03$
$=45{\cdot}87$ m^3

News & Views

Eighth Conference of Controllers of Weights & Measures

It has been decided to hold the eighth Conference of Controllers of Weights and Measures on 5, 6 and 7 March 1964, at Agra. Among the points which will come up for discussion are:

(1) Review of progress.

(2) Definition of the term 'transaction for trade' in Weights and Measures (Enforcement) Acts of the States.

(3) Classification of weighing machines used in industry according to use—that is, whether they are used in transactions for trade or not.

(4) Verification of net contents of sealed packages.

(5) Consideration of a proposal to do away with commercial brass weights (other than bullion weights) of the denominations 20 g to 1 kg, and to introduce a cast iron weight of 20 g.

(6) Consideration of a proposal to dispense with plating in the case of brass measures and to prescribe a procedure for testing the amount of plating in steel measures.

(7) Test weights and measures, for verifying measures and weighing and measuring instruments.

(8) Amendment of the Weights and Measures (Enforcement) Rules.

(9) Whether special balances should be provided for weighing precious stones.

(10) Marking of glass measures by etching.

(11) Sale of beam scales by capacity.

A review of the proceedings of the Conference will appear in the May 1964 issue of *Metric Measures*.

Report on Decimal Currency in UK

The Committee of Inquiry on Decimal Currency for UK set up under the Chairmanship of Lord Halsbury in December 1961 has now submitted its report.

The Committee has recommended, by a majority of four to two the adoption by the

UK of a £—cent—1/2 cent system, i.e. the present £ would be divided into 100 cents and the cent being further divided into 1/2 cent equal to 1.2 pence. The final choice of nomenclature, however, has been left to the Government and the people. The coinage would consist of three bronze coins of 1/2, 1 and 2 cents and three cupro-nickel of 5, 10 and 20 cents.

It is further recommended that decimalisation should be preceded by a three-year preparatory period calculated from the date of the Government announcement and followed by a period not exceeding 2 years when dual currency would be in use. The earliest year for the Decimalisation Day, according to the Committee, would be 1967.

The measureable costs, i.e. of conversion or replacement of £. s.d. business and coin-operated machines and of manufacturing decimal coins would increase, the Committee states, as the Decimalisation Day is postponed. In 1967, it would be £ 109 million, in 1968 £ 114 million and in 1970 £ 128 million. It is also recommended that official conversion tables should be issued with alternative tables for those organisations which wish to ignore half cents. Retailers should adopt dual price marking before and after the change-over, but this should not be mandatory.

The Report estimates that in 1962, there were in use 32,000 weighing machines operated mostly by pennies. Over 3 lakh price computing scales and over 50,000 price computing petrol pumps would require conversion. The total conversion and replacement cost for all machines is estimated to be around £ 66 million.

The two dissenters to the majority report in a special memorandum claim 10 s-cent system to be the best available and point out that the £—cent—1/2 system is not a pure decimal system although the majority had noted that the 1/2 cent would disappear due to normal inflation. The majority view is that it is important and essential to retain the status of the £ abroad and that dropping it would induce sinister dealings in sterling to the detriment of the economy. The dissenters do not agree with this.

(Condensed from *The Monthly Review*, October 1963, pp. 233-234).

The Thermometer—From Florence to Lyons

A very interesting history of the thermometer by M. Danloux Dumesnils, is reported in the *Bulletin Belge de Metrologie*. In it the author suggests that the real inventor of the Celsius scale (named after a Swede) was actually a Frenchman named Christin.

M. Maurice Jacob, in a commentary on the history, points out the truth of the saying 'No man is a prophet in his own country' in its application to thermometers. In France at the present moment they are using a scale attributed to a Swede, Celsius; the Germans have for a long time remained faithful to that of the Frenchman REAUMUR, and the British still use that of the Prussian FAHRENHEIT. Mention is made of the cautious introduction of the terms 'Celsius' and 'Centigrade' here.

(from *The Monthly Review*, October 1963, pp. 237)

BROCHURE ON THE INTRODUCTION OF METRIC SYSTEM IN THE HIGHWAYS DEPARTMENT (English)—published by the Highways Research Station, Highways & Rural Works Department Government of Madras, Madras; Sept. 1963; pp 148.

This brochure which is a 'Special Report' published by the Highways Research Station, Madras, is an extremely important document and deserves the attention of the Highways Departments of other States as well.

It is divided into five main sections as follows:

I. Introduction
II. Madras Highways Manual—Volume I.
III. Specifications for Works and Method of Measurement and Payment
IV. Method of Measurement and Tolerances.
V. Tables.

After considering in detail the various steps to be taken, the Highways Department changed over to the metric system from 14 November 1962 on the following lines:

(1) All works under execution were to be continued till completion in the F.P.S. system with the same conditions and contract to avoid complications that would arise.

(2) The works for which estimates were sanctioned in F.P.S. system prior to 14-11-62 and tenders not settled, tendering was to be called for in metric units by converting the quantities but the work was to be executed in the F.P.S. system. Payment was expected to be in the C.G.S. system.

(3) All estimates sanctioned after 14-11-62 should be in C.G.S. system.

As a result of this programme of change-over, it was necessary to effect changes in the Schedule of Rates, Road Metal Rate Book, the Manuals, specifications and designs.

To facilitate the change-over, a large number of tables had to be prepared for many items of work and materials in terms of metric units to replace tables which were based on the F.P.S. system. The Madras Highways Manual—Volume I had to be amended to a certain extent.

The Chapter on 'Specifications for Works and Method of Measurement and Payment' contains considerable information which every Highway Engineer will find of interest and use to him. What is more, illustrative examples are given to explain the points made out.

The book is also embellished with 31 useful tables. Besides the usual conversion tables, there are tables to convert feet and inches into millimetres up to 10 feet by steps of 1/16 of an inch. Besides, a table of conversions from 0 to 1,000 feet, in steps of 10 feet is also provided. Other tables relate to various types of speeds, volumes, pressures, stresses etc. Such important information as weight, perimeter and area of metric steel bars, weight of reinforcement for square metre of slab, safe permissible loads on masonry and soils, road metal rate book, sample schedule of rates, conversion of prices per 1,000 or 100 cubic feet to cubic metre as also from 100 square or running feet to square metres or metres etc. is included in the book. This Section also contains information on sample estimate for special repairs to road work, sample estimate for constructing a building, typical worked out examples on reinforced concrete slab in metric system as also a worked out example for hydraulic calculation for bridge estimate.

This is the first book of its kind which has been published in India so far. It is exhaustive and is a mine of information for engineers. It deserves the attention of all who are concerned with Highways work.

VOLUME TABLES FOR ROUND OR SQUARED TIMBER UNDER METRIC SYSTEM—PART-I (English); Compiled by T. Janaky and published by Bharathee Bhooshanam Press, Viyyur (P.O.) Trichur, Kerala State; Price Rs. 8; June 1963; pp. 321.

The author has compiled tables covering girths from 21 centimetres to 180 centimetres in steps of 1 centimetre and lengths from 5 centimetres to 15 metres in steps of 5 centimetres. The volume of the timber is given correct to three decimal places as was decided in the Conference of Conservators of Forests held on 19 December 1961 in New Delhi.* The quarter girth formula has been used for working out the volumes.

An interesting feature of these tables is the calculation of co-efficient of girths for one metre length. These co-efficients have been calculated for mid girth ranging from 1 cm to 180 cm. From this co-efficient, the volume of any length of log can be worked out simply by multiplying the co-efficient by the length in metres and putting the decimal point in the correct place. This section of the tables covers four pages while another two pages are devoted to conversion factors and tables of British and metric units. The main tables for volume calculations run to 321 pages.

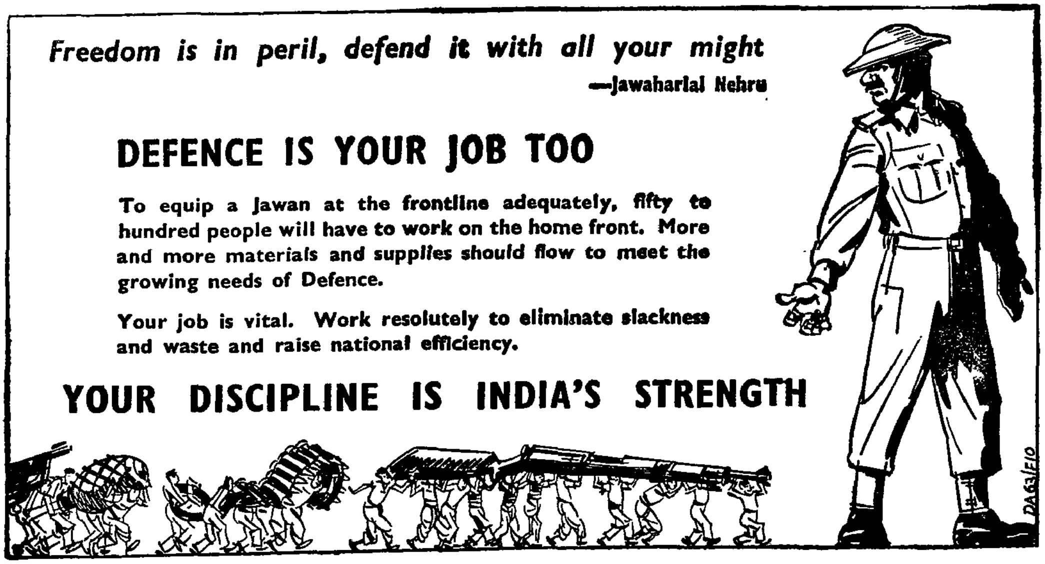
The volume tables are very exhaustive and it is obvious that the compiler has taken great pains to put all these values together.

These tables have been approved for use by the Kerala Forest Department and deserve the attention of other States as well.

The book has been printed in such a size that it is easy to locate the values at a glance. Each column gives values in steps of 2.5 metres which leads to ease of reference.

The book is printed in easy to ready type and can be conveniently carried about by users.

*See *Metric Measures*, Vol. 5, No. 2, pp. 18 & 19, 1962.



M164DPD/63—GIPF.

ISI

CONVERSION SLIDE

A UNIQUE INSTRUMENT FOR INTER-CONVERSION OF VALUES

A **MUST** for all engineers, designers and constructors in India and abroad, wherever inter-conversion of values from metric to non-metric units or vice-versa is a matter of routine.

Quantities Covered include:

Length—mile, foot, inch (decimal and fractional), kilometre, metre and millimetre.

Area—Square inch, square foot, square centimetre and square metre.

Volume—Cubic foot and cubic metre.

Capacity — Gallon (UK) and litre.

Weight—Pound, seer, maund kilogram and quintal.

Pressure & Stress—Pound per square inch, ton per square inch, kilogram per square centimetre and kilogram per square millimetre.

Gauges—Birmingham (BG), British Standard Wire (SWG), American Brown & Sharpe (AWG), and Indian Standard Thicknesses and Diameters of wire.

Temperature—Fahrenheit and Centigrade.

PRICE—Only Rs 15.00 plus postage.

For enquiry and order, please write to

INDIAN STANDARDS INSTITUTION

MANAK BHAVAN, 9 BAHADUR SHAH ZAFAR MARG, NEW DELHI-1

Branch Offices : BOMBAY • CALCUTTA • KANPUR • MADRAS

TYPICAL METRIC PRICING UNITS FOR WHOLESALE TRANSACTIONS

Serial No.	Commodity	Metric Unit
(1)	**Gold**	10 grams (g)
(2)	**Grocery and Confectionery** Biscuits, sweetmeats, cardamoms. **Textiles and Textile Fibres** Cotton yarn, damaged and seconds cloth, raw silk, rayon silk yarn, raw wool, wool manufacturers (when sold by weight). **Paints & Chemicals** Paint (if sold by weight), indigo, liquid chlorine. **Hides, Skins & Leather** Raw hides, leather (hides and skins). **Metals** Silver, aluminium sheets, strips and circles, copper and brass wires and utensils. **Miscellaneous** Tea, meat, camphor tablets, mica.	1 kilogram (kg)
(3)	**Grains and Pulses** Rice, wheat, jowar, arhar, moong, masur, gram. **Spices** Black pepper, mustard, chillies, dhania, dalchini, turmeric, betelnuts. **Plantation Products** Rubber, cashewnuts, cashew kernels, tobacco (raw and manufactured). **Forest Products** Lac and lac products, gums, myrobalans, galnuts, soapnuts. **Textiles & Textile Fibres** Raw jute, raw-hemp, coir yarn. **Oils, Oilseeds & Oilcakes** Vegetable oil, oilseeds, oilcakes. **Non-Ferrous Metals** *Aluminium:* ingots, bars, blocks, slabs, billets. *Lead :* ingots, sheets and strips. *Copper :* ingots, blooms, slabs, cakes, tiles, bricks, billets, blisterbars and wirebars, rods, sections and pipes, plates, sheets and strips, circles. *Brass :* ingots, rods, sections, pipes, sheets, strips, circles. *Zinc :* ingots, sheets, strips. *Tin :* blocks. **Chemicals** Caustic soda, bleaching powder, glycerine, soaps, paper salt. **Others** Sugar, gur, ice, fish, sugarcane, vegetables, tamarind.	1 quintal (q) (100 kilograms)
(4)	**Minerals** Iron ore, manganese ore, bauxite, coal. **Iron & Steel** Pig iron, iron & steel manufactures, semis (billets for rerolling etc.)	one metric tonne (t) (1,000 kilograms)
(5)	Cloth (mill, handloom, silk rayon and woollen cloth)	1 metre (m)
(6)	Jute carpets, coir mats and mattings, sheet glass.	one square metre (m^2)
(7)	Timber.	one cubic metre (m^3)
(8)	Paints (when sold by measure), spirits.	one litre (l)

Weights

(1) In place of the present units of seer, pound, rattal, viss etc., use the kilogram.

(2) In place of the tola, use the gram or 10 grams.

(3) In place of maund or corresponding unit, use the quintal *i. e.* 100 kg.

Capacity Measures

In place of seer or gallon or any other measure use the litre.

Length Measures

(1) Use the metre in place of yard or foot and the centimetre in place of inch.

Square Measures

(1) Use the square metre in place of square yard or square foot, and square centimetre in place of square inch.

Cubic Measures

(1) Use the cubic metre in place of cubic yard or cubic foot and cubic centimetre in place of cubic inch.

Packaging

It is advantageous if sizes of packages correspond to series of commercial weights and measures prescribed.

These are: 50 kg, 20 kg, 10 kg, 5 kg, 2 kg, 1 kg, 500 g, 200 g, 100 g, 50 g, 20 g, 10 g, 5 g, 2 g, 1 g, and so on.

TYPICAL PRICING UNITS FOR RETAIL TRADE

Serial No.	Commodity	Metric Unit for Use
(1)	Foodgrains, cereals, pulses, spices, ghee, bread, vegetables, meat, fish, sweetmeats, tea, coffee, sugar, salt.	1 kg
(2)	Oil for cooking	1 kg or 1 litre depending upon prevalent practice.
(3)	Fruits	1 kg or number depending upon prevalent practice.
(4)	Milk	1 litre
(5)	Cloth and related materials	1 metre
(6)	Prepa materials	Preferably sizes corresponding to series of commercial weights and measures.

Publishe by the Director, Publications Division, Ministry of Information and Broadcasting, Delhi and printed by the Manager, Government of India Press, Faridabad.
Registered with the Registrar of Newspapers for India under No. 977/58.